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MEASUREMENT OF Δm_d USING A PROBABILITY BASED SAME-SIDE TAGGER APPLIED TO LEPTON+VERTEX EVENTS

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A measurement of Δm_d is performed using inclusive lepton+vertex events at CDF. A probability based Same-Side Tagger was developed to tag the initial b-flavor of the B^0_d, which suppresses tagging on B-decay products. We find $\Delta m_d = 0.42 \pm 0.09 \pm 0.03\ \mathrm{ps}^{-1}$.

Measurement of the B^0 oscillation frequency Δm, as well as CP-violation tests, critically depend on determining both the initial and decay "b-flavor" of the meson, with the initial flavor tag usually the principle difficulty. We report a new Δm_d measurement[1] using a modified version of "Same-Side" flavor tagging adapted to the challenging problem of tagging an inclusive lepton+vertex B sample.

The data ($\sim 100\ \mathrm{pb}^{-1}$) are from the 1992-6 Tevatron run. B-selection mimics an earlier analysis[2], and consists of e and μ triggers with $p_t(\ell) > 6$ GeV. Tracks are clustered into jets. Jet tracks within $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2} < 0.7$ of the lepton are tried for vertexing if their impact parameter to the primary vertex is $> 2\sigma$. Secondary vertices pass into our sample if the lepton is in the vertex, and it has a transverse decay length > 2.5 mm. This results in 59,881 e and 63,674 μ events.

This sample has quite high b-purity, with contaminants determined as follows: the $c\bar{c}$ component by the secondary vertex mass distribution ($4 \pm 1\%$ for e, $8 \pm 2\%$ for μ); electron conversions from dE/dx ($0.8 \pm 0.1\%$); fake e fraction also from dE/dx ($0.4 \pm 0.2\%$); and the fake μ fraction is determined from the final Δm_d fit[a] ($4 \pm 6\%$).

The initial flavor tag used is a variant of our previous Same-Side Tagging (SST).[3] The idea[4] is that the *flavor* of a B meson is correlated to the *charge* of a nearby particle. This may be due to: a) B^{**} decay, or b) fragmentation where the type of B meson (determined by the light quark) leaves a corresponding light antiquark nearby whose type determines the sign of the $\pi^\pm$ formed. These process will produce $B^0\pi^+$ pairs, and not $B^0\pi^-$'s. This type of correlation was first seen by OPAL[5] in $e^+e^- \to Z^0 \to b\bar{b}$, and also in fixed target hadroproduction of charm.[6]

A specific SST tagging algorithm ("p_T^{rel}") was used by CDF to measure Δm_d in a nearly exclusive $B \to \ell D^{(*)} X$ sample,[3] as well as in our $\sin(2\beta)$ measurement.[7] The issue here is: can SST be used in an inclusive lepton+vertex sample given the significant danger of selecting a charge correlated B-decay product as the tag?

[a] The sensitivity to the fake μ-fraction basically arises from the difference in the apparent tagging dilutions observed in the e and μ samples.

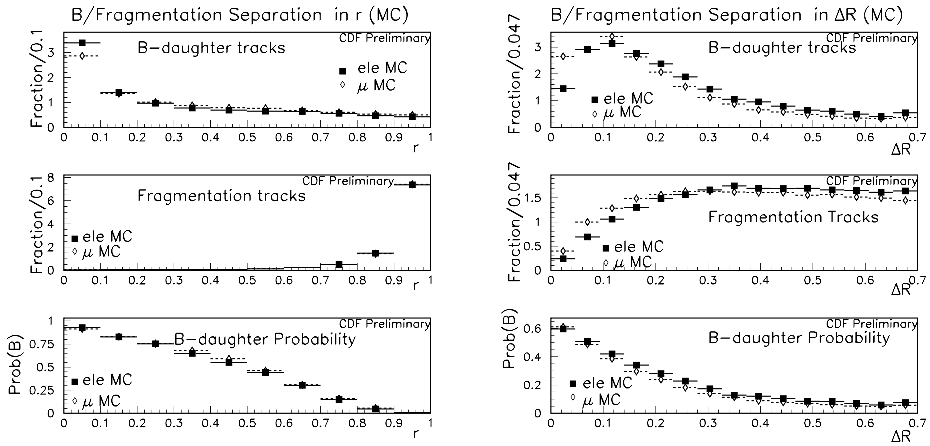

Fig. 1. The behavior of B-daughters (top), fragmentation tracks (middle), and the probability of being a B-daughter (bottom) as calculated from Monte Carlo in the r and ΔR variables.

The p_T^{rel}-algorithm considered tracks with $p_t > 400$ MeV, to be within $\Delta R < 0.7$ of the B, have an impact parameter to the primary vertex $< 3\sigma$ in the transverse plane. From this set of tracks, a single track was selected as the tag based on the minimum p_T^{rel}.[3] This last criteria is prone to select B daughters, thus instead of the p_T^{rel} selection we take all accepted tracks and impose the additional probability cut on the track to not be a B-daughter: $\mathcal{P}_B(r, \Delta R) < 0.3$. In this case *more* than one track may be selected, and the tag sign is the *sum charge of all accepted tracks.*

The cut on $\mathcal{P}_B(r, \Delta R)$ suppresses B daughters as tag tracks, and is defined as:

$$\mathcal{P}_B(r, \Delta R) \equiv \frac{B(r, \Delta R)}{B(r, \Delta R) + F(r, \Delta R)}, \quad \text{with} \quad r = \frac{d_B/\sigma_B}{d_{pv}/\sigma_{pv} + d_B/\sigma_B}$$

where d_B (d_{pv}) is the track impact parameter relative to the B (primary) vertex, σ it's error, and ΔR defined as usual. $B(r, \Delta R)$ and $F(r, \Delta R)$ are the respective numbers of B and fragmentation tracks in r and ΔR; their behavior is shown in Fig. 1, as well as the probability of being a B-track. The function $\mathcal{P}_B(r, \Delta R)$ is the correlated 2-dimensional distribution, but only the projections are shown in Fig. 1.

With a tagged sample we compute the usual "mixed"/"unmixed" asymmetry ($\mathcal{A}$) in proper-time bins. The apparent proper-time is corrected for lost decay products by the usual methods (the "k-factor"). The raw asymmetry of the data is the sum of all sources; that from B_d^0's is $\mathcal{A}_0 = \mathcal{D}_0 \cos \Delta m_d t$, where $\mathcal{D}$ is the "dilution" (*i.e.* $\mathcal{D} = 1 - 2P$, with mistag probability P). Asymmetries due to B^+, B_s^0, Λ_b, and charm are included in the model, and while these have constant intrinsic asymmetries their fractional contributions or dilutions can be time dependent. This model is fit to the data using a binned χ^2, with Δm_d, $\mathcal{D}(B^0)$, $\mathcal{D}(B^+)$, and the fake-μ fraction free. The result is shown in Fig. 2, which compares well with other single tag CDF analyses in Fig. 3. The B^0 dilution is found to be $13 \pm 3^{+2}_{-1}\%$, barely 1σ smaller

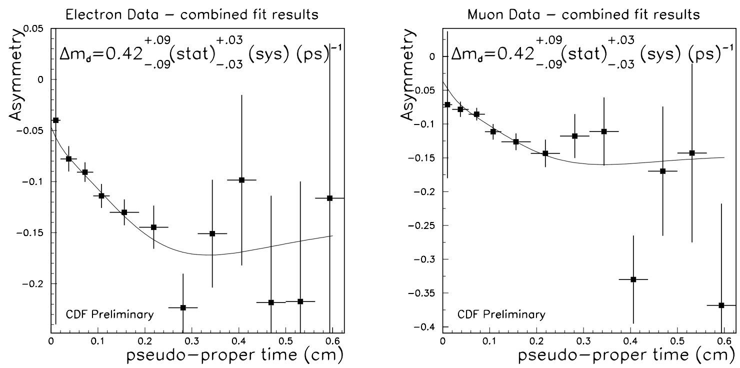

Fig. 2. The raw asymmetry of SST tagged lepton+vertex data (left: e; right μ) fit to model of B^0 oscillations and B^+, B_s^0, Λ_b, charm components. The e and μ data are fit simultaneously (note the different vertical scales).

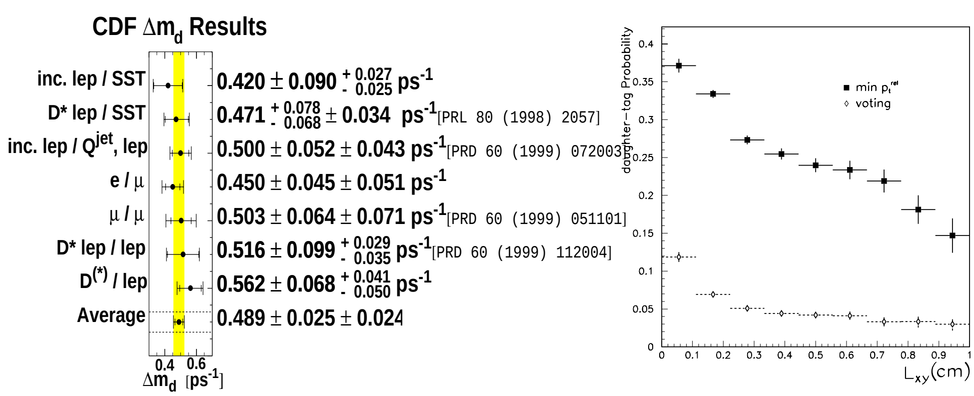

Fig. 3. Left: Summary of CDF Δm_d analyses. Right: Probability of tagging on a B-daughter for the p_T^{rel} vs. probability SST in the ℓ+vertex sample as a function of transverse decay length.

than in the "p_T^{rel}" SST applied to $\ell D^{(*)}$ events.[3] But, as seen in Fig. 3, this new "voting" method greatly suppresses tagging on B-daughters in ℓ+vertex events.

References

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